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Influence of Added Co Substrates, Technical and Technological Factors on the Fermentation Process of Municipal Wastewater Sludge

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Abstract

The potential of the sewage sludge as energy resource is not exploited. There are studies that confirm that it is possible to increase the yield of the fermentation process if the conditions are appropriate. This paper presents the specific factors that need to be modified in order to improve the efficiency as well as the materials and the methods that have to be used to achieve the improvement.

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Kewords: biogas; sewage sludge; fermentation; methane; wastewater

1. Introduction

Biogas is a renewable and sustainable energy carrier generated via anaerobic digestion (AD) of biomass [1]. There are at least five main biomass resources from which biogas can be produced, i.e. sewage, landfill, livestock manure, organic wastes and energy crops. Depending on its origin biogas comprises methane (40–75%), carbon dioxide (20–45%) and some other compounds, usually in trace quantities [2].

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On the other hand, the disposal of the different types of organic sludge produced from sewage has become one of the largest problems of environmental management, including gases emissions generated by sewage sludge management [3]. In rural areas, the public wastewater treatment plants also face problems related to the management of sewage sludge. The common technologies used for sludge dewatering in sludge ponds and wetlands do not provide the required parameters of dry matter to continue managing it. This situation is caused mainly by the influence of very unstable atmospheric conditions. The use of fermentation process to obtain biogas from sewage sludge is an alternative in the management of sludge [4]. It also gives additional benefits associated with obtaining thermal energy and biogas. The biogas plants that use sewage sludge operate near big urban wastewater treatment plants with large and excessive initial sludge production [5]. In small wastewater treatment plants the use of that technology is currently not profitable because they do not have enough sludge production.

There are a growing number of biogas plants working with wastewater treatment plants and relatively low efficiency of currently operating biogas plants or those under construction. An example of low efficiency of the currently applied technologies is very high content of organic matter in fermented sewage sludge and the fact that after drying it can be used as solid bio-fuel. During a well performed fermentation process the degree of mineralization of the substrate should be much higher.

There are a lot of studies that say the use of appropriate technical factors (e.g. breaking material with ultrasounds, heat treatment or other supplements that optimize the physical or chemical parameters of fermenting input) can significantly increase the efficiency of fermentation and the amount of obtained methane even with small funding [6]. That is why it is necessary to do research that aim to increase the fermentation performance of sewage sludge. The study will use the sewage sludge as mono-substrate or with addition of other substrates coming from the communal water treatment, including green waste (grass, leaves), which management creates a big problem for most municipalities in Poland.

2. Methodology

The assumption is that the use of technical factors in the typical fermentation of sewage sludge in wastewater treatment plants will optimize the fermentation technology and will produce greater amount of bio-methane from the same amount of waste sludge. To achieve the objective of the work it will be necessary to do the following research:

- The analysis of the stages of methane fermentation based on sewage sludge in typical facilities for fermentation of sewage sludge (expected cooperation with Aquanet Poznan and other wastewater treatment plants).
- Research on the influence of the main treatment of the sludge on the efficiency of the fermentation process using ultrasonic, thermal and pressure techniques.
- Investigation of the influence of the added substrates (grass, leaves and other public waste) on efficiency of the fermentation process and the amount of obtained bio-methane.
- Analysis of technical factors influencing the fermentation of sludge (temperature, pH, dry matter content, C / N, etc.) with the aim of optimizing the production of methane.

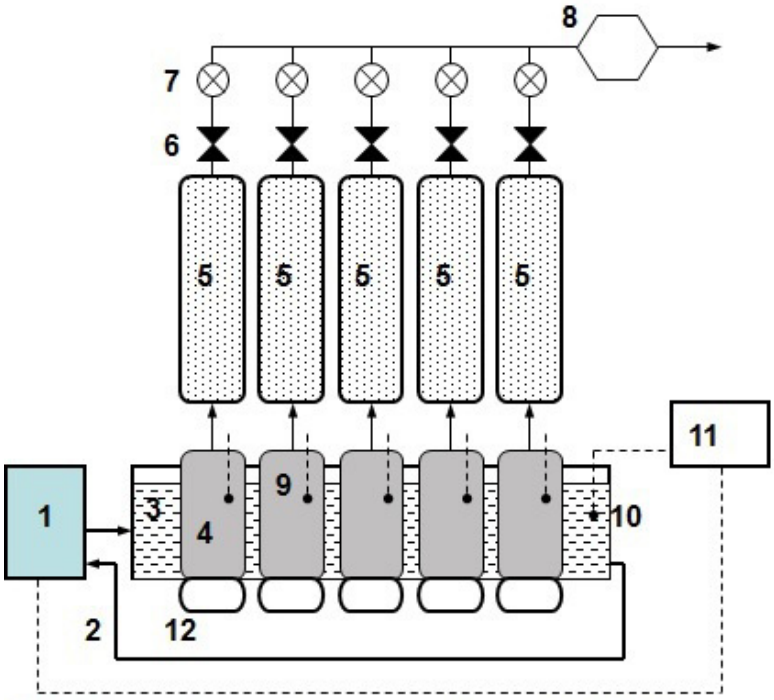
3. Materials and methods

In the experiments there will be used machinery and equipment for research on methane fermentation process that are in the eco-technology laboratory at the Institute of Bio-systems Engineering in Poznan University of Life Sciences (PULS). It will be based on internal procedures according to DIN 38 414. The investigation will be carried

out in multi-chamber bio-fermenter created by the laboratory crew (Fig 1). The produced biogas enters into the containers made from Plexiglas filled with neutral liquid, the level of which decreases while the amount of gas increases. The analysis of gaseous emissions (CH_4; CO2; NH_3; O_2; H_2S) will be conducted in the gas analyzer which consists of a suction pump and several electro-chemical sensors that allow to determine gas concentration in the fermenter [7]. During the investigation the following parameters of the substrates and fermenting pulp will be analyzed: dry matter/humidity (drying method PN-75 C-04616/01), pH (potentiometer method PN-90/A-75101.06), conductivity (PN-EN 27888:1999), organic matter and ash (burning method according to the modified PN-Z-15011-3).

For primary treatment of sewage sludge there will be used heat treatment devices (pasteurizer), ultrasound (sonifier) and pressure (macerator).

The bio-fermenter chambers will be in a layer of heated water with controlled temperature. Thus, it is possible to investigate mesophilic (range 35-41°C) and thermophilic (52-63 °) processes.



1.Water heater with temperature controller 2.Isolated hot liquid tube 3.Layer of water at temperature of 36-41° 4.Biofermenter with the input of 2dm³ 5.Biogas container 6.Safety valves 7.Biogas flow meter 8.Gas analyzer (CH4, CO2, NH3, H2S, O2) 9.PH sensor 10.Temperature sensors 11.Controlling and registering central 12.Input magnetic stirrer

Fig. 1. Bio-fermenter scheme (5-chamber section).

4. Discussion

These are the scientific premises for increasing the efficiency of biogas production on the basis of substrate sludge in the system with biomass from agricultural production. The results will allow to choose the best combination to increase the profitability of investments in biogas plants installed at small wastewater treatment plants. The aim of the study is to obtain the efficiency of methane fermentation thanks to which creating such plants will be profitable.

There are over 80 biogas plants in Poland working at municipal wastewater treatment plant. The potential of growing is huge because in Poland there are over 3000 wastewater treatment plants where sewage sludge is barely useful.

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